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(Revision of ANSI C63.2-1980)

American National Standard

for instrumentation— electromagnetic noise and field strength, 10 kHz to 40 GHz— specifications

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ANSI C63.2-1987
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American National Standard for Instrumentation—

Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz— Specifications

Accredited Standards Committee On Electromagnetic Compatibility, C63

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Foreword

(This Foreword is not part of American National Standard C63.2-1987.)

Almost from the beginning of radio broadcasting, the electric utility companies were faced with problems of radio noise. In 1924 the National Electric Light Association appointed a committee to study the subject. The manufacturers of electric power equipment had encountered similar problems, and in 1930, a subcommittee of the NEMA Codes and Standards Committee was set up. The following year, the EEI-NEMA-RMA Joint Coordination Committee on Radio Reception was organized.

The Joint Coordination Committee issued a number of reports, among which was *Methods of Measuring Radio Noise, 1940.* This report included specifications for a radio-noise and field-strength meter for the frequency band 0.15–18 MHz. The report recommended procedures for measuring radio-noise voltage (conducted noise) from low- and high-voltage apparatus, making noise field-strength measurements near overhead power lines, determining broadcast field strengths, and collecting data upon which to base tolerable limits for radio noise. More than a thousand radio-noise meters were built, essentially in conformance with those specifications. They have been used to make extensive field, factory, and laboratory tests on many types of electrical apparatus.

During World War II, the needs of the armed services for instruments and methods for radio-noise measurement, particularly at frequencies higher than the broadcast band, became pressing and, in 1944, work on developing suitable specifications was begun by a special subcommittee of ASA Sectional Committee C63, Radio-Electrical Coordination. This special subcommittee developed a war-time specification which became the joint Army-Navy Specification JAN-I-225 which was issued in 1945 and later approved as American War Standard — Method of Measuring Radio Interference of Electrical Components and Completed Assemblies of Electrical Equipment for the Armed Forces from 150 kc to 20 Mc, C63.1-1946. This American War Standard included the specifications for a radio-noise meter similar to those included in the JCC 1940 report with the addition of some refinements and improvements.

In 1950, the ASA Sectional Committee C63 completed preparation of Proposed American Standard Specifications for a Radio Noise Meter, 0.015 to 25 Mc / s, C63.2, which was published in March 1950 for trial and study. An effort was made to take advantage of the extensive experience with meters made under the specification in the 1940 report as well as advances in radio engineering practice.

Experience with the proposed standard indicated a number of needed revisions and improvements. The various branches of the Armed Forces had developed new specifications for radio-noise meters since 1950, and the International Electrotechnical Commission published for CISPR (International Special Committee on Radio Interference) *Specification for CISPR radio interference measuring apparatus for the frequency range 0.15 Mc/s to 30 Mc/s,* Publication 1, First edition, 1961. The revised standard was published as American Standard Specifications for Radio-Noise and Field Strength Meters 0.015 to 30 Mc / s, C63.2-1963. In 1964, standard C63.3, covering instruments for the frequency range 20 MHz to 1000 MHz was issued, which was based upon the principles of measurement used in standard C63.2. More recently, CISPR Publication 16 has been issued.[1]

The experience with meters made under the specifications set forth in the 1950 Proposed American Standard and the advances in radio engineering practice evidenced by these newer specifications for radio-noise meters have resulted in the inclusion of a number of revisions and improvements in this standard.

This standard was developed by Subcommittee One on Techniques and Developments of Accredited Standards Committee on Radio-Electrical Coordination, C63.

Methods of measurement in the frequency range of up to 1 GHz are covered in ANSI C63.4-1981, Methods of Measurement of Radio-Noise Emissions From Low-Voltage Electrical and Electronic Equipment in the Range of 10 kHz to 1 GHz. Methods of measurement up to 40 GHz are under consideration.

[1] See [4] in Section 19.

At the time that the Accredited Standards Committee on Electromagnetic Compatability, C63 approved this standard it had the following membership:

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American National Standard for Instrumentation—

Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz— Specifications

1. Introduction

The increasing significance of electromagnetic compatibility considerations in the design and application of electrical and electronic equipment is directly related to the expanding sophistication of the functions performed by such equipment in industrial, civilian, and military activities. In order to enable the designer and user to be assured that equipment of concern to them will function in the intended application, it is necessary to control the electromagnetic environment adequately. The environment will vary from one application to another, as will the performance requirements. For this reason a variety of electromagnetic compatibility techniques and instruments are necessary. This specification describes requirements for instruments measuring quasi-peak, peak, rms and average values. Which of these will need to be included in any one instrument will depend upon the application.

The quasi-peak detector yields a measure roughly correlated to the subjective annoyance effect on AM broadcast services. It has also found restricted use for measuring interference in television.

The peak detector has been applied in those situations in which a very low repetition-rate pulse can produce significant effects, such as in the case of non-redundant data-transmission formats. Peak measurements are used for military and some industrial applications, including measurement of ignition interference.

The rms and average values are used extensively for environmental survey work. The interference frequently arises from numerous independent impulsive sources occurring at random. If the spectra of the sources are broadband and relatively flat and produce time responses that overlap in the IF amplifier, the rms and average levels measured vary approximately as the square root of the bandwidth. For the case of non-overlapping responses, the rms indication still varies with the square root of the bandwidth, but the average value is independent of bandwidth. The rms value is used for determining interference effects on some communication channels. The average value is widely used in measurements of AM emissions.[2]

2. Scope

This standard delineates the requirements of electromagnetic noise instrumentation for the frequency range of 10 kHz to 40 GHz incorporating quasi-peak, peak, rms and average detectors.

NOTE: Examples of the types of voltages, currents, and fields to be measured are unmodulated and modulated sine waves, and components of electric and electromagnetic disturbances, including transients which may interfere with the operation of communication, electric, or electronic equipment.

The basic instrument is a frequency-selective voltmeter. With appropriate coupling devices, such as antennas and current probes, the instrumentation will also measure other physical quantities such as field strength and current.

The parameters for the quasi-peak detector

[2] Additional discussion of the application of various detectors is given in ANSI C63.12-1984 [1]. (Numbers in brackets correspond to those in the bibliography in Section 19.)

are specified to agree with the requirements of the *Comite International Special des Perturbations Radioelectriques* (International Special Committee on Radio Interference) (CISPR) [4]. An optional discharge time constant is specified also.

The requirements of this specification should not be construed to imply that one instrument is to cover the entire frequency range or that the instrument is permitted to have only the specified detector or detectors. Many users have measurement requirements over a smaller frequency range or may require additional detection capabilities.

Although spectrum analyzers are frequently used in electromagnetic-noise measurements, it is not the purpose of this standard to cover such instruments. A separate document covering spectrum analyzers for use from 20 Hz to 40 GHz is in preparation as a proposed amendment to C63.2.

3. General

3.1 Basic Instrumentation. Each instrument shall consist of a manually or automatically tuned frequency-selective voltmeter with the characteristics as specified in this standard, and as summarized in Table 1.

Accessory equipment shall be available for each type of instrument as indicated in Table 4.

3.2 Units of Measurement. The output meter scale shall indicate voltage as an absolute magnitude and in decibels referenced to 1 μV, for example: $dB(\mu V) = 20 \log_{10} V/10^{-6}$ where V is in volts. Each pickup device shall be supplied with calibration curves to convert the indicated voltage to the appropriate electromagnetic quantity being measured.

3.3 Calibration. The measuring set shall be supplied with sine-wave, impulse, or other equally reliable means of substitution calibration for each measured level at any frequency. The substitution voltage shall be available to be applied to either the voltage or field-strength sensor input or equivalent circuit. The instrument shall be supplied with calibration curves that enable measurements of both narrow band and broadband radio interference to the specified accuracies. The basic calibration shall be in terms of the rms value of a sine wave.

4. Frequency Ranges

The frequency range of individual instruments may cover any portion of the overall frequency range and may tune below 10 kHz or above 40 GHz. Based upon user applications and radio-frequency spectrum use, it is suggested that individual instruments cover one of the following tuning ranges:

(1) 20 Hz to 10 kHz (to be considered)
(2) 0.010 to 0.150 MHz
(3) 0.150 to 30 MHz
(4) 30 to 515 MHz
(5) 470 to 1000 MHz
(6) 1 to 40 GHz (18 to 40 GHz optional)

When the tuning range of an instrument is divided into two or more bands, an overlap of at least 2% between adjacent bands is required, except for the optional 18–40 GHz frequency range, where overlap shall be not less than 10 MHz. The instrument shall provide continuous coverage within its frequency range. The indicated frequency shall be accurate to within ± 2%.

5. Amplitude Range

The two-terminal-voltmeter amplitude range of the instrument shall be from 0.5 μV to 1 V (0.1 μV to 1 V in the frequency range 0.01 to 0.15 MHz). The total amplitude range is a function of the sensitivity, attenuators, and output-meter range as set forth below. The overall amplitude accuracy shall be ± 2 dB as a voltmeter or ± 3 dB as a field-strength meter.

For impulsive noise, the input voltage range shall be from at least 50 dB(μV/MHz) to 140 dB (μV/MHz). The sensitivity shall be measured with a pulse rate of 60 pulses/s ± 20% to provide a pulse-count change greater than 2:1 from noise *on* to *off*. The minimum dynamic range of the RF circuits shall be 80 dB and of the IF circuits shall be 60 dB.

A logarithmic (dB) scale having a range of at least 40 dB is desirable. For quasi-peak measurements, a calibrated linear scale shall be provided.

6. Input Impedance

The standard input impedance for all instruments for use as a two-terminal voltmeter shall

Table 1
Summary of Characteristics for Quasi-Peak, Peak, RMS and Average EMI Instrumentation

Characteristics	0.010–0.15 MHz	0.15–30 MHz	30–515 MHz	470–1000 MHz	1–18 GHz	18–40 GHz	Notes
1. Input impedance	50 and 600 Ω	50 Ω	50 Ω	50 Ω	50 Ω	Standard waveguide	
2. Attenuator range	As required to give on-scale reading for 1 V input	→	→	→	→	→	
3. Output meter range	40 dB minimum	→	→	→	→	→	
4. RF input voltage range	0.5 μV to 1 V	→	→	→	1 μV to 1 V	→	
5. RF sensitivity	0.5 μV	→	→	→	2.2 μV	3.0 μV	INT noise (referred to 50 Ω) ≤ specified level
6. RF preselector	Yes	→	→	→	→	Optional	
7. RF bandwidth	Compatible with IF BW	→	→	→	→	→	
8. RF Dynamic range	80 dB	→	→	→	→	→	
9. Spurious-free dynamic range	60 dB	→	→	→	→	→	
10. LO leakage	5 μV	→	→	→	50 μV	TBD†	Measured without RF attenuation
11. RF tuning overlap	2%	→	→	→	→	10 MHz	For bands within 1 set
12. Overall frequency accuracy	± 2%	→	→	→	→	→	
13. Overall voltage amplitude accuracy	± 2 dB	→	→	→	→	→	Including calibrator
14. Overall field strength accuracy	± 3 dB	→	→	→	→	→	
15. IF bandwidth quasi-peak	200 Hz	9 kHz	120 kHz	120 kHz	N/A	N/A	6 dB bandwidth
average, peak and rms	1 and 10 kHz	1 and 10 kHz	10, 100, and 1000 kHz	100 and 1000 kHz	100 kHz, 1000 kHz, and 10 MHz	→	6 dB bandwidth
16. Linear IF dynamic range (QP)	60 dB	→	→	→	N/A	N/A	
log IF dynamic range (peak)	60 dB	→	→	→	→	→	
crest factor (rms)	20 dB minimum	→	→	→	→	→	
17. Detector time Constant quasi-peak	45/500 ms	1/160* ms	1/550 ms	→	N/A	N/A	
Detector integrating time rms and average	0.1–100 s	→	→	→	→	→	
18. Output Meter Time Constant quasi-peak	160 ms	→	100 ms	→	N/A	N/A	
average, rms, peak	Short as possible	→	→	→	→	→	
19. Audio and IF output	Yes	→	→	→	→	→	
20. V_d output (rms detector only)	Optional	→	→	→	→	→	Ratio of rms to average
21. Calibrator	Impulse or sine wave	→	→	→	→	→	
22. Unit of measurement	Microvolt or dB (μV)	→	→	→	→	→	
23. Power supply	100–125V, 48–450 Hz	→	→	→	→	→	Batteries recommended
24. Sensors	Rod, Loop, CP, VP	→	Dipole, Bicon, CLS, CP, VP	→	CLS, WGH	WGH	CLS = conical log spiral CP = current probe VP = voltage probe WGH = waveguide horn
25. Accessories	Yes	→	→	→	→	→	

*See Section 9.1.1.
†TBD = To Be Determined.

be 50 Ω. If other impedances are provided, it is recommended that they be standardized at 75, 150, 300, 600 and 10 000 Ω. These input impedances may be obtained via external matching networks or internal circuits of the instrument. In the 0.01 to 0.15 MHz frequency range, a 600 Ω balanced input impedance shall be provided in addition to 50 Ω unbalanced.

Above 1 GHz, input VSWR at control settings for maximum sensitivity typically shall not exceed 2:1, and at no frequency shall exceed 3:1. Above 18 GHz, input connections shall be compatible with standard waveguides.

7. Selectivity and Bandwidth

The overall selectivity, sensitivity, and spurious responses are a function of the RF bandwidth and the IF bandwidth. Since each instrument may cover several decades of frequency, several different RF and IF bandwidths may be required. The selectivity shall be obtained without the use of stagger-tuned or overcoupled circuits. As a minimum, the 3 dB and impulse bandwidths must be given as a function of frequency.[3]

7.1 RF Bandwidth. An RF preselector shall be used before any amplification stage in each instrument. The bandwidth of each preselector shall be as narrow as possible to reduce spurious responses, and yet wide enough to ensure that the specified overall bandwidth before detection is maintained. RF preselection shall be optional in the optional coverage range of 18–40 GHz.

7.2 Overall Bandwidth

7.2.1 Quasi-Peak Detector. The bandpass characteristics for each indicated frequency range shall be as shown below, with tolerances as shown in Figs 1, 2 and 3.

Frequency Range (MHz)	Bandwidth −6 dB
0.010–0.15	200 Hz
0.15–30	9 kHz*
30–515	120 kHz
470–1000	120 kHz

*See pp 15 and 16.

7.2.2 Peak, RMS, and Average Detectors. The bandpass characteristics shall be:

Frequency Range (MHz)	Bandwidth* −6 dB
0.010–0.15	1 and 10 kHz
0.15–30	1 and 10 kHz
30–515	10 and 100 kHz
470–1000	100 and 1000 kHz
1000–40 000	100 kHz, 1000 kHz, and 10 MHz**

* Tolerance ± 10%.
** Tolerance on 10 MHz bandwidth is +100%, −10%. Actual impulsive bandwidth to be specified ±10%.

8. Spurious Responses

The rejection ratio to signals at frequencies more than 20% from the tuned center frequency shall be 60 dB minimum throughout the frequency range of the instrument. This requirement is applicable to intermodulation, image, IF feedthrough, tuned signal into IF, and similar spurious responses. This requirement is not applicable to image rejection in the 18–40 GHz frequency range.

9. Detector Circuits

9.1 Quasi-Peak Detector Circuit

9.1.1 Circuit Time Constants. The quasi-peak detector circuit shall have the nominal characteristics for the frequency ranges indicated in Table 2.

The charge time constant is the time needed, after the instantaneous application of a constant RF sine-wave voltage at the instrument input, for the output voltage to reach 63% of its final value.[4]

The discharge time constant is the time needed, after the instantaneous removal of a constant sine-wave voltage applied to the input of the measuring set, for the output voltage to fall to 37% of its initial value.

In the special case of interference or radio influence voltage (riv) measurements associated with electrical power apparatus, interference meters with quasi-peak detector time constants of 1 ms charge and 600 ms discharge and having

[3] Methods of measuring the impulse bandwidth are given in ANSI/IEEE Std 376-1975 (R1981) [3].

[4] Methods of measuring charge and discharge time constants are given in Appendix A.

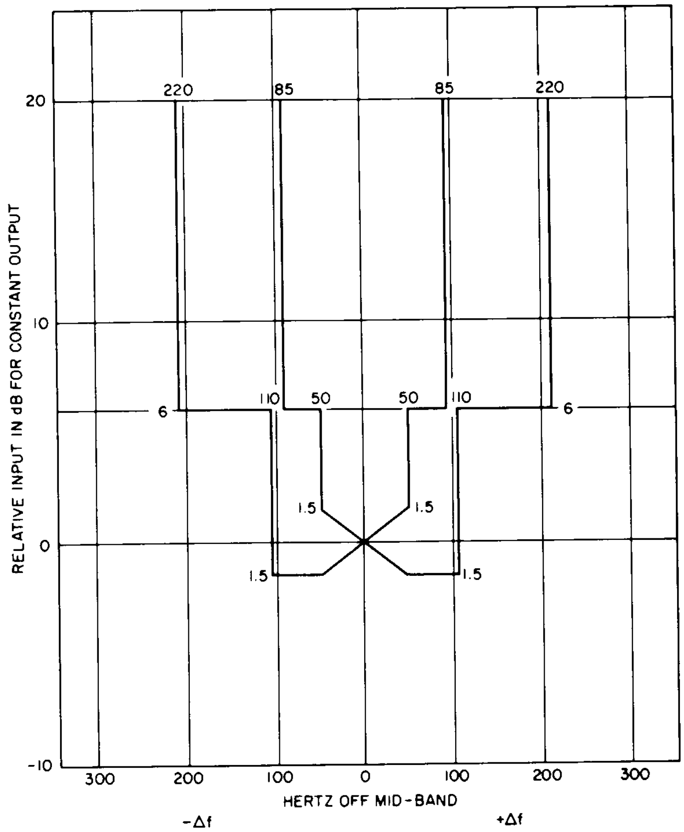

Fig 1
Limits of Overall Selectivity (Pass-Band)
Frequency Range, 0.010–0.15 MHz

Table 2
Nominal Circuit Time Constants

Frequency Range (MHz)	Charge Time Constant	Discharge Time Constant	Optional Discharge Time Constant
0.010–0.15	45 ms	500 ms ± 20%	
0.15–30	1 ms	160 ms ± 20%	600 ms ± 20%
30–515	1 ms	550 ms ± 20%	
470–1000	1 ms	550 ms ± 20%	

6 dB bandwidths of ~ 4.5 kHz are also used at frequencies near 1 MHz. As explained in the NOTE below, such a meter reads essentially the same as one meeting CISPR requirements (1 ms/160 ms time-constants, ~ 9 kHz, 6 dB bandwidth) for most types of electrical discharges.

NOTE: In the United States, radio-interference meters operating at a frequency near 1 MHz are used for quality control and radio-interference measurements from high voltage (hv) electrical power apparatus, such as extra-high voltage (ehv) power lines, power transformers and switch-gear. The most common interference instruments used in the power industry today have quasi-peak detector time constants of 1 ms charge and 600 ms discharge, and 6 dB bandwidths of ~ 4.5 kHz. In contrast, CISPR requirements have quasi-peak detector time constants of 1 ms charge, 160 ms discharge, and a 6 dB bandwidth of 9 kHz.

These instruments, or their equivalents, have been in use for many years, and it has been demonstrated by numerous studies [6], [7], [9], [10] both in the United States and Europe, that for most electrical discharges associated with

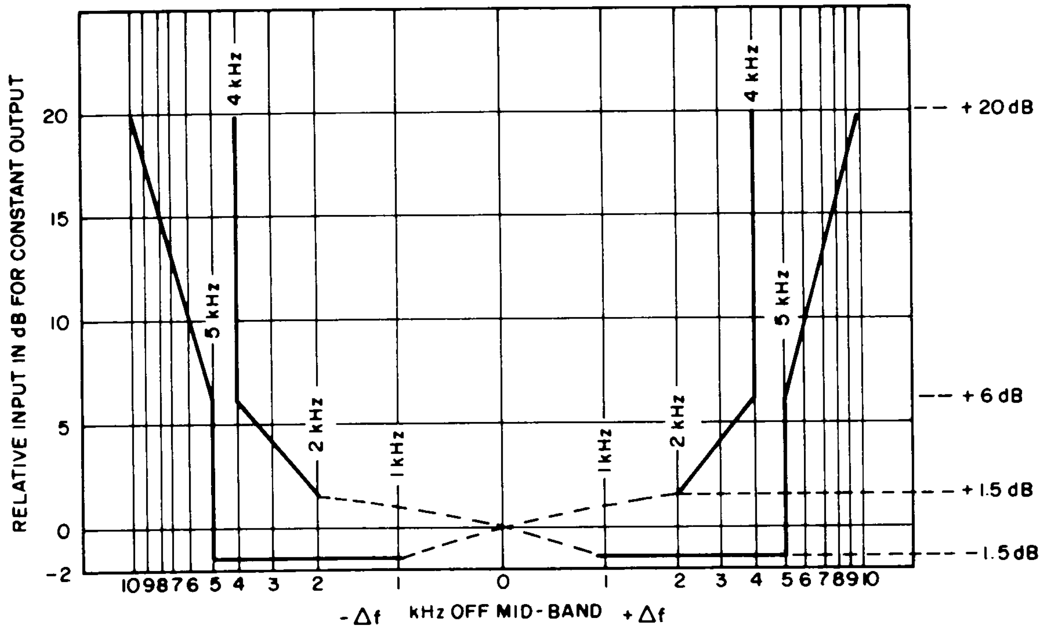

Fig 2
Limits of Overall Selectivity (Pass-Band), Frequency Range 0.15–30 MHz

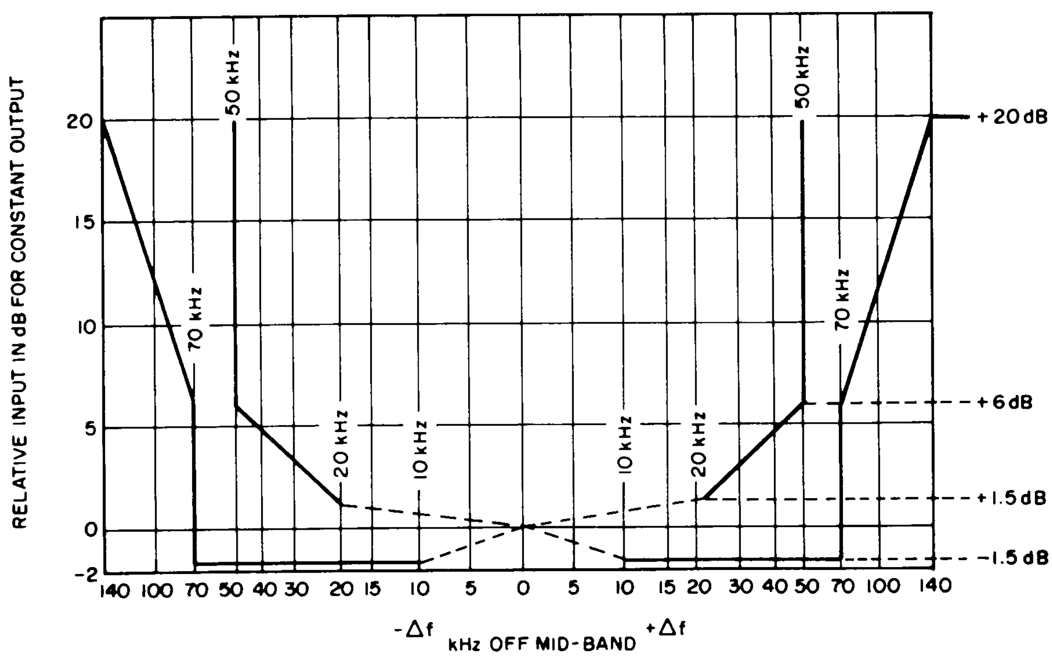

Fig 3
Limits of Overall Selectivity (Pass-Band), Frequency Range 30–1000 MHz

power apparatus, measurements with either the United States or European instruments will yield almost identical[5] results at pulse repetition rates close to the power frequencies (60 to 180 Hz). At other pulse repetition rates there will be a difference between the two instruments as demonstrated by Fig 8 of [9]. Fig 4 shows the pulse-response characteristic required from an instrument with a 600 ms discharge time.

9.1.2 Pulse Amplitude Response. The response of the instrument to pulses of the amplitude specified below,[6] and with a uniform spectrum throughout the frequency range specified, and with a pulse repetition rate as specified shall, for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency, from a signal generator having an emf of 2 mV rms and the same output impedance as the pulse generator. When the output impedance of the generator is equal to the input impedance of the instrument, the rms sine-wave signal at the input to the instrument will be 1 mV.

Frequency Range (MHz)	Pulse Amplitude* μVs	dB(μV/MHz)	Repetition Rate (Hz)
0.015–0.15	13.5	139.6	25
0.15–30	0.316	107	100
30–1000	0.044	90	100

*There is a 3 dB difference between the two values because the calibration is in terms of the value of the rms equivalent sine wave.

9.1.3 Pulse-Repetition-Rate Response. The response of the instrument with the quasi-peak detector to repeated impulses shall be such that for a constant indication on the instrument, the relationship between amplitude and repetition frequency shall be between the limits shown in Table 3.

9.1.4 Meter Time Constant. A selectable averaging time-constant range of 0.1 to 100 s shall be provided.

9.2 Peak Detector. The peak-detector circuit may be one of two types.

[5] This is so because the shorter discharge time constant and wider bandwidth of the European instrument compensate for the longer discharge time constant and narrower bandwidth of the American instrument. If either the bandwidth or time constants are changed, then measurements with the two instruments would not correlate.

[6] For operational calibration, lower amplitude signals (0.1 mV) may be used.

9.2.1 Direct Peak. The direct-peak-detector circuit shall have a charging circuit with a time constant in s that is short with respect to the reciprocal of the widest bandwidth in hertz. The discharge time constant (that is, peak hold) shall be a minimum of five times the time constant of the output indicating device. A *peak-hold* circuit with *dump* circuit is recommended. Manual control of the discharge or *dump* time constant, either as a step function or continuously variable, is recommended.

9.2.2 Manual Slideback Peak. The manual slideback-peak circuit can be either a back bias to the detector circuit or a comparator circuit for determining the peak of the noise envelope. Either aural or visual indication of the threshold point may be employed. The bias or comparator signal shall be used to control the output indication of signal level.

The peak detector shall provide a reading within 2 dB of peak at a pulse rate of 1 pulse/s for impulse noise with a uniform spectrum across the bandwidth of the instrument.

9.3 RMS Detector Circuit. The detector shall provide rms measurement for all types of signal modulation envelopes. A selectable integrating time-constant range of 0.1 to 100 s shall be provided.

9.4 Average Detector Circuit. The detector shall provide an average measurement of all types of signal modulation envelopes. A selectable integrating-time-constant range of 0.1 to 100 s shall be provided.

9.5 Audio Detector. The instrument shall provide an AM audio detector and a recorder output terminal. In addition, an FM audio detector is recommended for frequencies above 30 MHz. The audio amplifier shall be provided with a manual gain control. The output level shall be 10 mW minimum into a 600 Ω load.

10. Output Indicator

The indicator shall be critically damped with time constants of 160 ms for the 0.010–30 MHz range and 100 ms for the 30–1000 MHz range. In this mechanical time-constant specification it is assumed that the mechanical deflection of the indicator is linear with the input current. The use of an indicator having a different relationship between input current and deflection is not

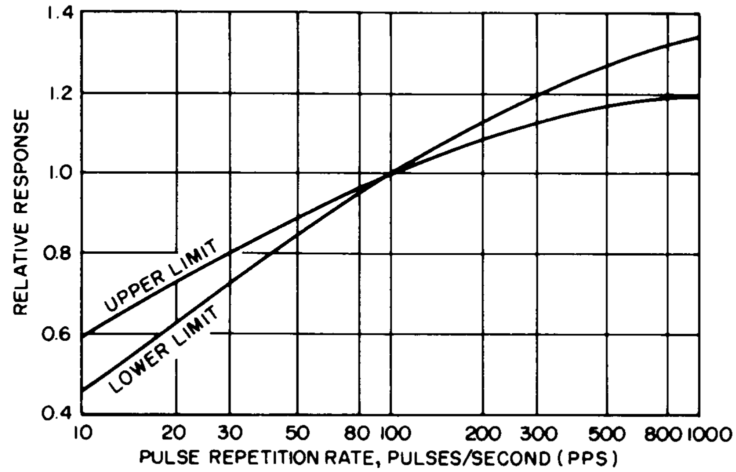

Fig 4
Response Characteristic for Quasi-Peak Circuit at 1.0 MHz (Discharge Time—600 ms)

Table 3
Pulse-Repetition, Rate Response

Repetition Frequency (Hz)	Relative Equivalent Level of Pulse (dB) 0.010–0.15 MHz	0.15–30 MHz	30–1000 MHz
1 000	*	−4.5 ± 1.0	−8.0 ± 1.0
100	−4.0 ± 1.0	0	0
60	−3.0 ± 1.0	*	*
25	0	*	*
20	*	6.5 ± 1	9.0 ± 1.0
10	4.0 ± 1.0	10.0 ± 1.5	14.0 ± 1.5
5	7.5 ± 1.5	*	*
2	13 ± 2.0	20.5 ± 2.0	26.0 ± 2.0
1	17 ± 2.0	22.5 ± 2.0	28.5 ± 2.0
Isolated Pulse	19 ± 2.0	23.5 ± 2.0	31.5 ± 2.0

* Indicates level is not specified for this frequency range.

precluded, provided the measuring set meets the requirements of this specification.

The time constant of the indicator can also be defined as being equal to the duration of a rectangular pulse (of constant amplitude) which produces a deflection equal to 35% of the steady deflection produced by a direct current having the same amplitude as that of the rectangular pulse.

11. Overload Characteristics

The upper range of practical circuit linearity is the maximum level at which the steady-state response of the circuit departs by more than one dB from ideal linearity. The ratio of this level to the level which corresponds to full-scale deflection of the indicating meter is called the overload factor of the circuit considered.

The minimum overload factor of circuits preceding the detector and for circuits between the detector and the output indicator shall be as given below.

11.1 Quasi-Peak Detector. With the quasi-peak detector, the overload factors shall be:

Frequency Range (MHz)	Circuits Before Detector	Circuits After Detector
0.010–0.15	24 dB	12 dB
0.15–30	30 dB	12 dB
30–1000	43.5 dB	6 dB

11.2 Peak Detector. For the peak detector, the overload characteristic is defined by the dynamic range of 60 dB and the spurious-response rejection of 60 dB.

11.3 RMS Detector. For the rms detector, the overload factor (ratio of peak-to-rms amplitude of the input signal) shall be 10 to 1, minimum.

11.4 Average Detector. For the average detector, the overload factor shall be at least 5 to 1.

12. Accuracy

The accuracy of pertinent parameters is described in the specific sections. The overall frequency accuracy shall be ± 2%. The overall amplitude accuracy shall be ± 2 dB as a voltmeter, and ± 3 dB as a field-strength meter.

13. Output Devices

In addition to the requirements for the output indicator in Section 10, the following shall be provided.

13.1 Peak Detector. The indicator response time and hold time shall be specified.

13.2 Other Outputs. Output connectors shall be provided for IF and video. These outputs are intended for connection to a high-impedance oscilloscope, or pulse counter. In addition, it should be possible to connect an external meter, or a 1 mA, 600 Ω input-impedance strip chart, or X–Y recorder to the detector output. The IF output should provide 60 dB dynamic range. An output level of 1 V (corresponding to full-scale indication) into a 91 Ω load is suggested. Bandwidth of all output circuits shall be consistent with IF bandwidth in use.

13.3 Digital Indicator. A digital output indicator may be used if it provides readings identical to those of the analog device.

14. Sensors

This section delineates the requirements for coupling devices used to measure voltage, current, power, or field strength.

The requirements of this specification should not be construed to imply that all specified sensors are required for each instrument. The type of sensors to be supplied with each instrument depends upon the user's application. Table 4 shows a listing of suggested sensors to be supplied for each frequency range.

14.1 Calibration Factors. Each sensor shall be provided with the conversion factor which is required to convert the indicated voltage value to the magnitude of the quantity existing at the input of the sensor (that is, volts per meter, amperes per meter, etc). The conversion factor shall consider all losses between the point of application and the input impedance of the measuring set.

14.2 Voltage Sensors. Voltage measurements of interference produced by devices or appliances normally connected to power lines are made by the insertion of a line impedance stabilization network (LISN) or artificial mains network between the power source and the equipment under test. The LISN passes power current while preventing the interference from the item under test from flowing into the power source, and preventing power-line electromagnetic interference (EMI) from influencing the measurement. The specific *R*, *L*, and *C* components required for the 50 Ω networks are listed in ANSI C63.4-1981 [2].

14.3 Current Sensors. Conducted interference current can be measured, without making direct contact with the source conductor and without modification of either the conductor or its circuit, by use of specially developed clamp-on current transformers, also known as current probes. They can be used to measure interference currents in the frequency range of 30 Hz to 1000 MHz, although the primary measurement range is 30 Hz to 100 MHz. Beyond 100 MHz the standing interference currents in conventional power systems require that the current-probe location be optimized for detection of the maximum interference current.

14.4 Power Sensors. An *absorbing clamp* may be used for measuring interference power conducted along a cable in the 30–300 MHz frequency range. A description of, and the arrangement for use of this device is given in C63.4-1981 [2]. The absorbing clamp is funda-

Table 4
Suggested Sensors to be Supplied for Each Frequency Range

Sensors	Frequency Range (MHz) 0.010–0.15	0.15–30	30–515	470–1000	1000–40 000
Rod antenna	Yes	Yes	No	No	No
Dipole Antenna‡	No	No	Yes	Yes	No
Biconical Antenna	No	No	Yes**	No	No
Log Periodic	No	No	Yes*	Yes	No
Conical Log Spiral	No	No	Yes*,§	Yes	Yes††
Loop Antenna	Yes	Yes	No	No	No
Voltage Probe	Yes	Yes	Yes	No	No
Current Probe	Yes	Yes	Yes†	No	No
Absorbing Clamp	No	No	Yes	No	No
Waveguide Horn	No	No	No	No	Yes

*Usually used only over 200–1000 MHz frequency range.

†Current probe may be used up to 100 MHz.

‡An isotropic (active) dipole may be used to avoid the necessity of orienting the dipole, provided it can be shown that reflections at the test site do not affect the result obtained as compared with a standard dipole, and that overload does not occur because of strong local signals.

§ For some applications, the circular polarization characteristic of this antenna is not acceptable.

**Upper frequency limit about 220 MHz.

††Upper frequency limit approximately 10 000 MHz.

mentally a current probe with a series of impedance stabilizing ferrite rings, which is positioned on the cable to absorb maximum power.

14.5 Field Sensors (see Table 4)

14.5.1 Rod Antennas. Rod antennas should be no more than 1.5 m in physical length and adjusted to give an effective length of 0.5 m when used in the mounting prescribed by the manufacturer. The effective length shall be determined by the standard-field method in accordance with acceptable standards, such as IEEE Std 291-1969 (R1981) [8].

NOTE: It is convenient to calibrate the instrument using an antenna by applying sine-wave voltage through a dummy antenna consisting of a capacitance equal to the capacitance-to-ground of the rod when used in the mounting prescribed by the manufacturer. Since the effective length is 0.5 m, the field strength in microvolts per meter is equal to twice the applied voltage in microvolts, which produces the same indication of the output meter as the field produced with the rod. The dummy antenna may be used as a high-impedance coupling device for voltage measurements, in which case the capacitor must be able to withstand the line voltage of the circuits on which the instrument is used.

Rod antennas are usable over the 10 kHz to 30 MHz frequency range. The calibrating factor shall be supplied for the entire usable frequency range specified by the manufacturer.

14.5.2 Loop Antennas. Loop antennas shall be electrostatically shielded. They shall be capable of being rotated at least 180°, independently of the instrument. The manufacturer shall furnish calibration data obtained according to a standard such as IEEE Std 291-1969 (R1981) [8].

NOTES: (1) Loop antennas are usually calibrated by placing a second loop antenna carrying sine-wave current at a specified distance and calculating the electromagnetic field at the location of the first antenna. The calculated field is expressed in equivalent micro-amperes per meter. It is desirable to design the instrument with loop antennas to measure the same range of field strengths as with the 0.5 m rod antenna.

(2) It is desirable to provide a shielded loop probe not over 5 cm in diameter for comparative readings only. The probe shall have sufficient insulation over its shielding so that it can be placed safely in contact with devices under test which operate at not over 600 V rms.

Loop antennas are usable over the 10 kHz to 30 MHz frequency range. The calibration factor shall be supplied for the entire usable frequency range specified by the manufacturer.

14.5.3 Dipole Antennas. Dipole antennas are recommended for the 30 to 1 000 MHz frequency range. The dipole length must be adjusted to resonance at each measurement frequency above 80 MHz. The dipole, when used below 80 MHz, should be used at the 80 MHz resonant length. The dipole shall be supplied with a calibration factor that considers the 80 MHz resonant length in the 25 to 80 MHz frequency region. The effective length shall also be considered in the conversion factor. IEEE Std 291-1969 (R1981) [8], provides a method for determining the effective length.

14.5.4 Broadband Antennas. Instead of dipole antennas which require mechanical adjustment, broadband antennas may be used above 30 MHz. A biconical antenna for the 30 to 220 MHz range and a conical logarithmic-spiral or log-periodic antenna, for the 200 to 1 000 MHz frequency range are recommended. Broadband antenna types recommended for frequencies above 1000 MHz are the conical logarithmic-spiral for 1–10 GHz, the double-ridged waveguide for 1–18 GHz, and matching waveguide horns for 18–40 GHz. It should be noted that use of the conical logarithmic-spiral type of antenna will result in the loss of polarization information. Antenna factors shall be supplied with each antenna. The procedure given in SAE-ARP-958 [11] may be used to obtain calibration data. Circularly polarized antennas, such as the conical logarithmic spiral, may not be acceptable for some applications.

14.6 Matching Networks. In the frequency range of 0.010 to 30 MHz, matching networks are required when the instrument input impedance is 50 Ω. The matching networks may be passive or active. When active matching networks are provided, the intermodulation and overload characteristics should be determined. The insertion loss or gain of each network should also be provided. The following matching networks should be available for purchase with each instrument:

150 Ω – 50 Ω
600 Ω – 50 Ω
10 000 Ω – 50 Ω

15. Shielding, Filtering, and Grounding

The instrument shall be shielded and input circuits shall be filtered so that an electric field of 10 V / m or a magnetic field of equivalent free-space value will not cause any response or undesirable operation within the set. The antenna input should be capped during this test. Care should be taken that the shielding is effective for frequencies outside of the frequency range of the instrument. A terminal shall be provided for grounding the instrument.

16. Power Supply

The instrument should operate on any supply voltage from 100 to 125 V (200 to 260 V is optional) single phase at any frequency from 48 to 450 Hz. It is recommended that instruments equipped with self-contained batteries be capable of satisfactorily operating the meter continuously for at least 10 h. If batteries must be replaced, serviced, or recharged periodically, the front panel should have a place to record the next servicing date and action. If rechargeable batteries are used, an indicator shall be provided to show the operating time available before recharging is required. In addition, provisions will be made either to change the internal batteries quickly or to operate from an external battery pack.

17. Safety Precautions

Precautions against electric shock hazard shall be taken when an ac operated power unit is used.

A shock hazard shall be considered to exist at any part subject to handling in normal use (not servicing) if the open-circuit potential to ground is more than 25 V and the current with a 1500 Ω load is more than 5 mA. Voltmeter terminals or ancillary coupling networks intended for direct connection to power circuits up to 500 V dc and 250 V rms ac at frequencies up to 800 Hz shall be capable of withstanding these voltages. Otherwise, the connection must be made through a capacitor that is capable of withstanding these voltages.

18. Environmental Requirements

Temperature	0 °C to 55 °C
Vibration	EIA RS-414-A [5]
Shock	EIA RS-414-A [5]
Transportation	EIA RS-414-A [5]
Moisture Resistant	55 °C at 90% relative humidity

19. Bibliography

[1] ANSI C63.12-1984, American National Standard Recommended Practice on Procedures for Control of System Electromagnetic Compatibility.

[2] ANSI C63.4-1981, American National Standard Method of Measurement of Radio-Noise Emissions From Low-Voltage Electrical and

Electronic Equipment in the Range of 10 kHz to 1 GHz.

[3] ANSI/IEEE Std 376-1975 (R1981), IEEE Standard for the Measurement of Impulse Strength and Impulse Bandwidth.

[4] CISPR Pub 16-1977 (first ed), Specification for Radio Interference Measuring Apparatus and Measurement Methods.

[5] EIA Std RS-414-A-1975, Simulated Shipping Tests for Consumer Electronic Products and Electronic Components. (Rescinded; informational only.)

[6] A Field Comparison of RI and TVI Instrumentation, prepared by a Task Force of the IEEE Radio Noise and Corona Subcommittee of the Transmission and Distribution Committee, Paper No F76-075-2, presented at the 1976 IEEE Winter Power Meeting.

[7] HARROLD, R. T. and DAKIN, T. W. The Relationship Between the Picocoulomb and Microvolt for Corona Measurements on HV Transformers and Other Apparatus, *IEEE Transactions on Power Apparatus and Systems,* vol PAS-92, no 1, pp 187–197, Jan/Feb 1973.

[8] IEEE Std 291-1969 (R1981), IEEE Standards Report on Measuring Field Strength in Radio Wave Propagation.

[9] NIGOL, O. Analysis of the Radio Interference From High-Voltage Lines, Parts I and II, *IEEE Transactions on Power Apparatus and Systems,* vol PAS-83, no 5, pp 524–541, May 1964.

[10] PRAUHAUSER, T. C. Measurement of Partial Discharges on Transformers and Their Elements, Part B: Comparison of Measuring Instruments and Circuits, CIGRE Paper No 12-10, June 1968.

[11] SAE-ARP-958, Broadband Electromagnetic Interference Measurement Antennas; Standard Calibration Requirements and Methods, Society of Automotive Engineers.

Appendix
Method for Determining Charge and Discharge Times of the Detector Circuit[7]

(This Appendix is not part of American National Standard C63.2-1988, but is included for information only.)

A1. Definition of Charge Time

The charge time is defined as the time required for the voltage on the output of the detector circuit to reach 63% of its final value after a sine wave is suddenly applied at the input of the last intermediate-frequency amplifier stage preceding the detector.[8] The advantage of this definition is that it includes the effects of the impedance reflected into the detector circuit from the coupling and output circuit of the last intermediate-frequency stage.

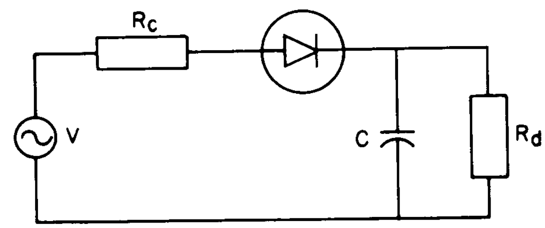

Fig A1
Typical Detector Circuit

A2. Typical Detector Circuit

Fig A1 is a simplified diagram of a typical detector circuit. Here the final intermediate-frequency amplifier stage and its coupling network to the diode are represented by the equivalent generator V and resistance R_c, where R_c includes the diode resistance (assumed constant during conduction) and the equivalent reflected resistance of the diode input circuit.

A3. Approximate Charge Time

The charge time is approximately (within the accuracy required for this specification) given by $4 \cdot R_c \cdot C$ (for closer values see A4). The factor 4 arises because the voltage applied to the circuit at V is effective in charging C only while the diode is conducting, and because a sine-wave input is used instead of direct current.

A4. Alternate Method for Determining Charge Time

As the technique required to measure charge time according to the above definition is not always easy to carry out, the following alternative method that determines R_c rather than the charge time may be used. With the automatic-gain-control circuit disconnected from the diode weighting circuit, an unmodulated radio frequency signal is applied at the input terminals of the meter. The discharge resistor R_d is replaced by a variable resistor having a maximum resistance of 10 MΩ or greater. The voltage V_m across the resistor with maximum resistance in the circuit is measured by a high-impedance direct-current voltmeter. The resistance is then adjusted until the voltage across it is $\frac{1}{2} V_m$. This value of resistance R' is then measured. Then

$$R_c = 0.216 R'$$

The product of $3.91 \cdot R_c \cdot C$ is the charge time when the ratio of charge time to discharge time is 1/160. The product of $4.05 \cdot R_c \cdot C$ is the charge time when the ratio of charge time to discharge time is 1/600.

[7] The material in Appendix A is based on information reported in Section A, pages 2–6, of the University of Pennsylvania *Progress Report No 8 of Investigations of the Measurement of Noise.* A Report of Development Work for the Period 15 March 1947 to 30 June 1947 under Contract NOBS 25397 with the Bureau of Ships, United States Navy, published June 30, 1947, by Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia.

[8] This definition is based on information in CISPR Pub 16-1977, see [4] in Section 19.

A5. Discharge Time

The discharge time may be measured by observing the time required for the voltage across R_d to decrease by 63% of its initial value after the removal of a sine-wave voltage at the input to the measuring set.

A6. Magnitude of Sine-Wave Voltage

In making the foregoing tests, the magnitude of sine-wave voltage applied should be such that, in the steady-state condition, full-scale deflection of the indicating meter will be obtained.